GPROF: PROGRESS TOWARDS AN IMPROVED OROGRAPHIC PRECIPITATION PRODUCT

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MOUNTAINS AND THE OROGRAPHIC RAIN INDEX

A mountain surface class

A new mountain surface type is being added to GPROF V7. It is defined using the USGS Global Mountain Explorer K3 resource. Regional landform modelling of 250 m elevation data produces the mountain regions shown in Figure 1. This class should provide a better representation of orographic precipitation.

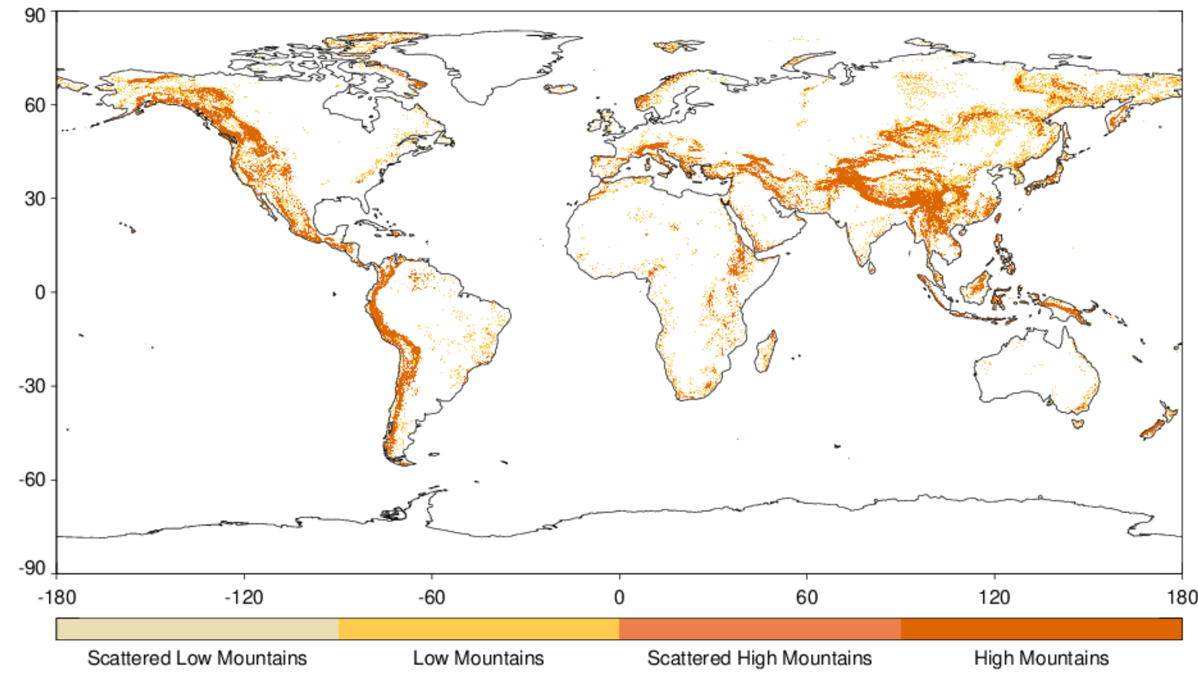

Figure 1. The K3 definition of global mountains used in GPROF V7 (Karagulle et al. 2017).

Orographic Rain Index

The Orographic Rain Index (ORI) is the product of moisture and terrain-induced lift (Bikos et al. 2014). It is derived according to the following:

- USGS GMTED ~1km resolution regridded to ERA5 resolution
- ERA5 data: TPW, *u* and *v* wind 1.5 km above surface
- ORI = TPW * V•∇H TPW: atmospheric moisture
- V•∇H: terrain-induced "lift" using u and v wind from 1.5 km above the surface from (*u*wind * xslope) + (*v*wind * yslope)

Figure 2 is an example of the ORI produced for an hour in 2019

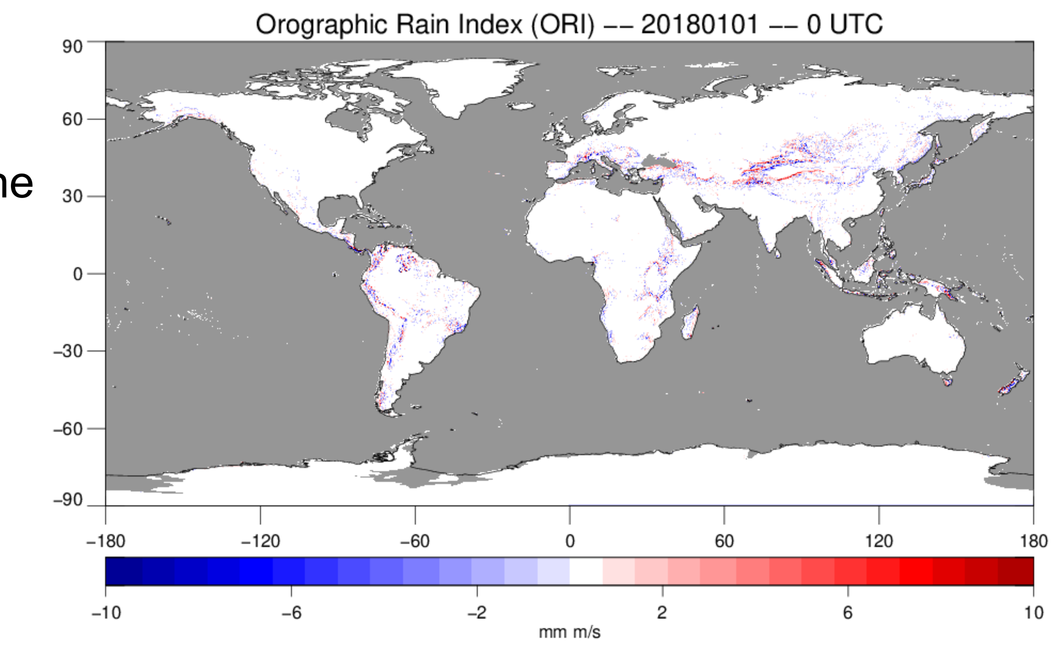

Figure 2. ORI values for 00 UTC 1 January 2018.

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PRECIPITATION CLIMATOLOGY OF WESTERN US

The western US is very mountainous and is a good region to evaluate different precipitation products. Hydrologists commonly use the Parameter-elevation Regressions on Independent Slopes Model (PRISM) to evaluate precipitation products in elevated regions, where orographic precipitation dominates the climatology. A comparison between the PRISM 4 km daily and higher temporal resolution hourly MRMS, HRRR and ERA5 products from October 2018 – September 2019 is made, as each of these could provide useful information when creating the mountain class database (Figure 3). ERA5 compares well to PRISM overall, but without the orographic patterns that HRRR shows. MRMS is not appropriate for mountain regions. Although some of these products many capture the overall climatology of precipitation, they may not get the weather systems creating them correct (Figure 4).

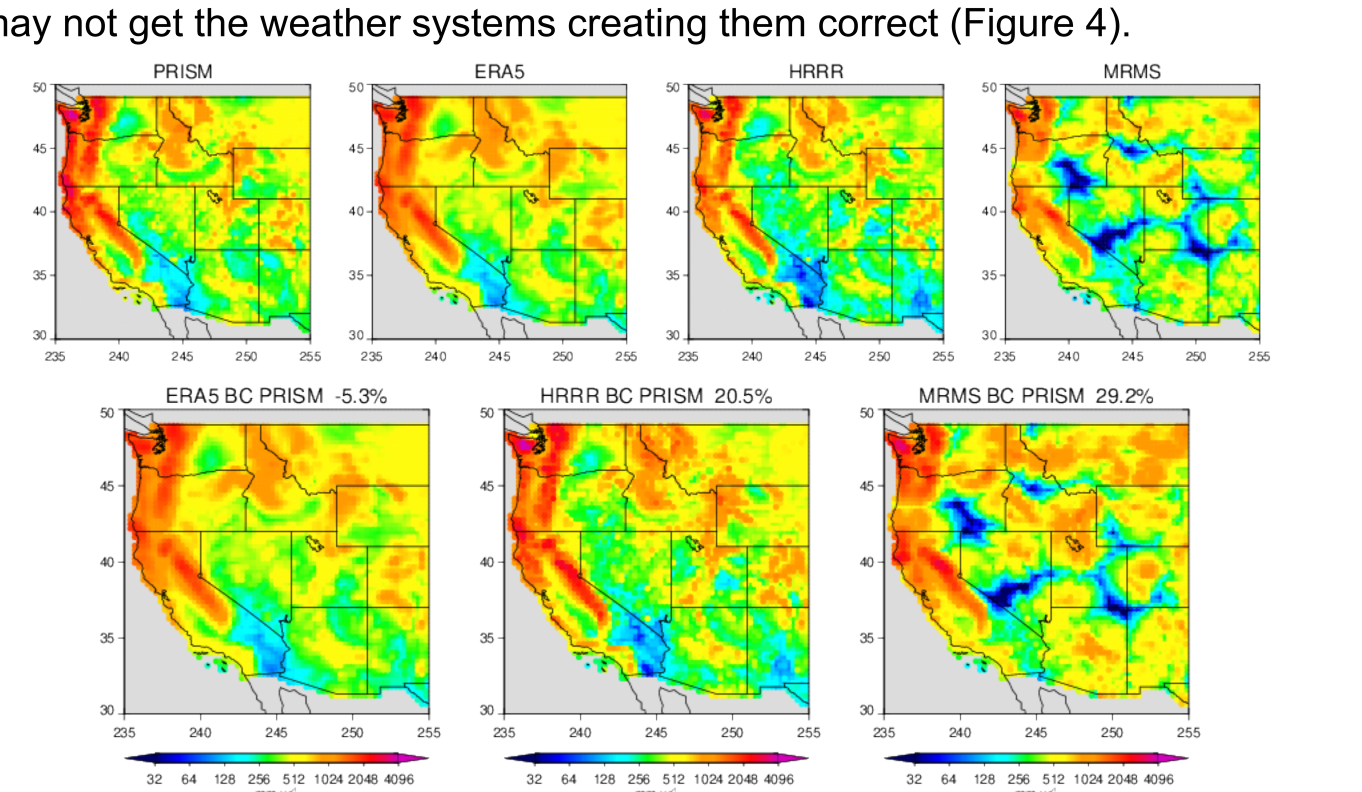

Figure 3. October 2018 – September 2019 precipitation climatology for the western US from PRISM, ERA5, HRRR and MRMS (top). A bias corrected climatology based on the percentage difference between the ERA5, HRRR and MRMS compared to PRISM is also shown (bottom).

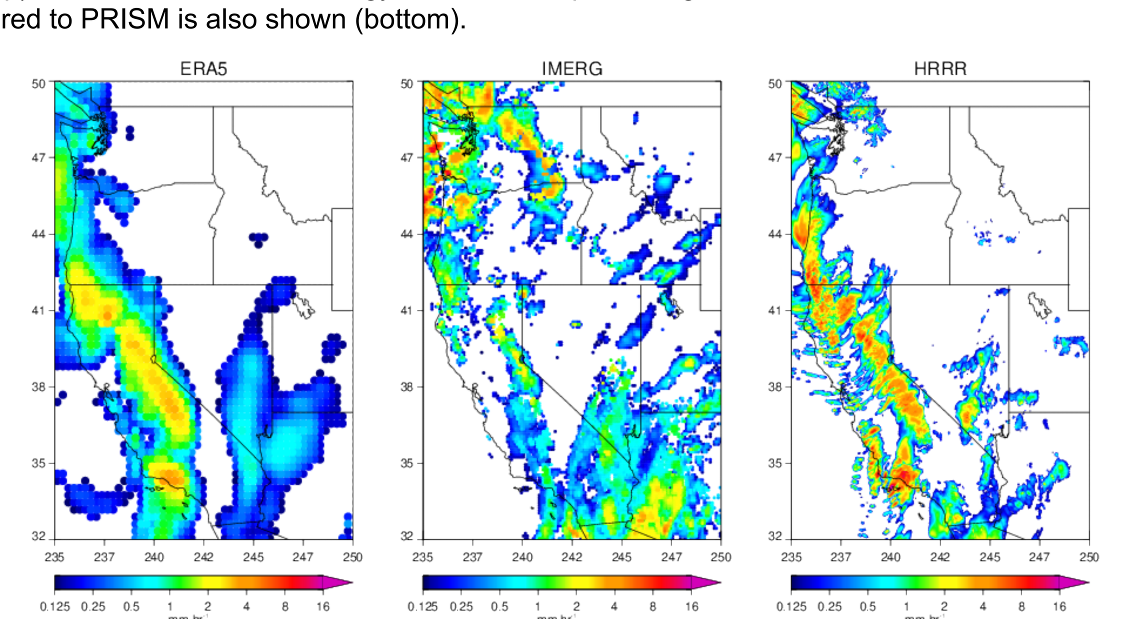

Figure 4. ERA5, IMERG and HRRR 1-hour precipitation rates for 03 UTC 6 January 2019.

DATABASE PRECIPITATION CLIMATOLOGY

Using the relationship between the precipitation climatology of PRISM and ERA5, the GMI mountain database precipitation can also be bias-corrected (BC). For a rain (May-Oct) and snow (Nov-Apr) season, the ERA5 BC climatology can then adjust the HRRR data, which in turn can be used to adjust the Combined ITE733 (CMB BC) data. Another alternative is to use the ORI values to adjust the CMB data relative to HRRR BC. Figure 5 shows these bias-corrections for the database period (October 2018 – September 2019) rain and snow seasons.

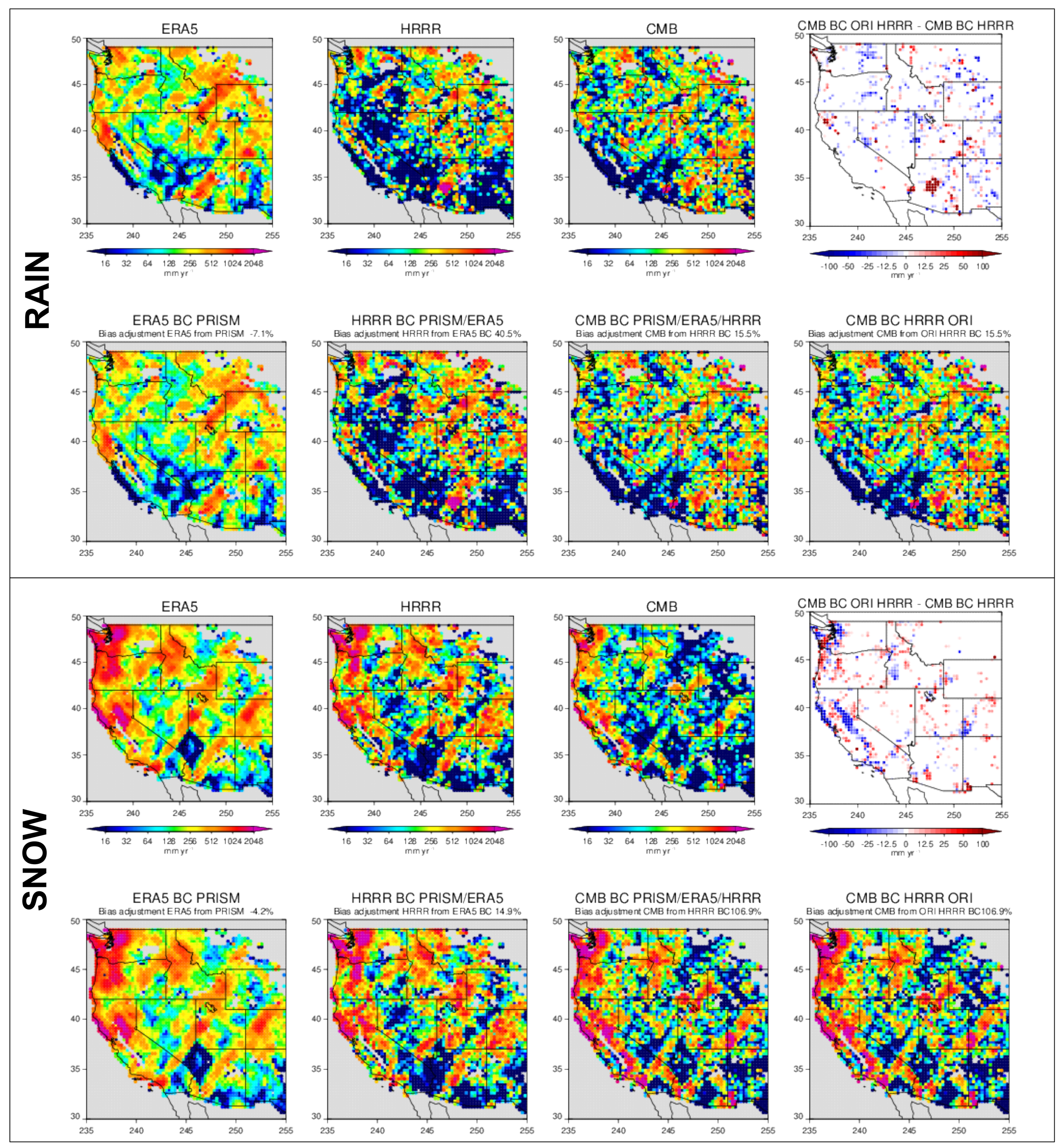

Figure 5. October 2018 – September 2019 mountain class rain and snow season precipitation climatologies for the western US from ERA5, HRRR and CMB (top panels). A bias-corrected climatology based on the percentage differences between the ERA5, HRRR and CMB (bottom panels). The top right panels compare the HRRR BC adjustment and the HRRR BC ORI adjustment.

DATABASE BIN PRECIPITATION RATES

Average precipitation rates of the GMI 2 meter temperature and total precipitable water database bins in Figure 6 show higher precipitation rates where ORI is larger than 5. Evidence of inhibited precipitation when ORI is negative is less apparent.

ORI indices

ORI 0: ORI <-5
ORI 1: ORI -5 – -0.25
ORI 2: ORI -0.25 – 0.25
ORI 3: ORI 0.25 – 5
ORI 4: ORI >5

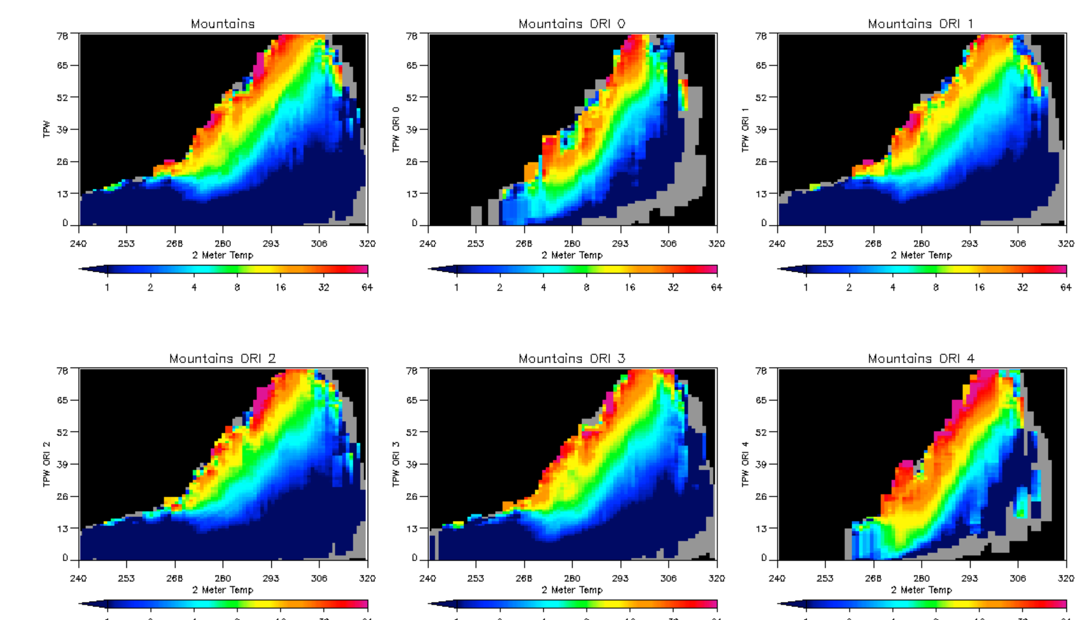

Figure 6. Average precipitation rates of the 2 meter temperature and total precipitable water database bins for all mountain profiles and the 5 mountain/ORI indices.

References

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FUTURE WORK

- Explore alternate orographic indices
- Test other sensors
- Run GPROF with the mountain and ORI database
- Compare the new mountain retrieval with GPROF V05